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The purpose of this natural and physical science course is to instill in the pupils an understanding of the purposes and methods of science rather than to impart a certain body of facts. Emphasis is placed upon classroom demonstration and experimentation so that the pupil will learn to think critically and to develop a questioning mind. Continuity of the three-semester program centers about those aspects of content common to all the sciences: science as the discovery of new facts by means of observation and experimentation; science as a method by which man attempts to define patterns describing the world; and science as it seeks order through classification schemes which illustrate the relationships in nature.

Each unit includes introductory material, concepts to be developed, and an outline of content. Units covered in the eighth grade include Ways of the Scientist, Building Blocks of the Universe, An Introduction to Living Things, Man and Space, Our Changing Earth, and Interrelationships of Living Things. The units for the ninth grade are Energy, Meteorology, and Frontiers of Science (Oceanography).

Included are methods for evaluating the achievements of the class, suggestions for providing a classroom laboratory experience, discussions of audiovisual materials and their uses, and safety regulations to be observed in the laboratory and classroom.

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JUNIOR HIGH SCHOOL

GENERAL SCIENCE

COURSE OF STUDY

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U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
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LOS ANGELES CITY SCHOOLS • 1963

JUNIOR HIGH SCHOOL

GENERAL SCIENCE COURSE OF STUDY

SCIENCE 1 - B8
2 - A8
3 - B9 or A9

Educational Materials Laboratory
Office of Education
JUN 1965
DEPARTMENT OF
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LOS ANGELES CITY SCHOOLS
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APPROVED:

ROBERT E. KELLY
Associate Superintendent
Division of Secondary Education

EVERETT CHAFFEE
Associate Superintendent
Division of Instructional Services

FOREWORD

A basic knowledge of science is fundamental to good citizenship and participation in today's society. General Science is a subject designed to provide a basic knowledge of science that will be useful in interpreting the environment and solving problems of daily living. It is required of all pupils.

The development of skill in critical thinking is a major purpose of the course. Laboratory activities which enable the pupil to develop skills in problem solving are an essential part of General Science. These activities contribute greatly to the understanding of basic science principles.

General Science is taught at the B8, A8, and 9th grade levels. An elective course is provided at the A9 level for pupils with a special interest in science.

EVERETT CHAFFEE
Associate Superintendent
Division of Instructional Services

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INTRODUCTION

Although the science program has been organized to insure appropriate scope and effective sequence, it is recognized that its interpretation is flexible. Each teacher may adapt unit material to meet the unique needs and abilities of his pupils. It is, however, expected that each of the units will be covered during the semester.

The content is developed as Resource Units.* Provision is made for both teacher demonstration and pupil participation. Although a sequential teaching plan is developed, in which questions and problems are assigned to cover the entire unit, the most effective teaching develops from problems which emerge from varied class activities and pupil-teacher exploration. It is hoped that, by the use of these units in planning, many teachers will be assisted in developing a problem-solving approach to subject matter which will involve greater pupil participation.

Basic Assumptions

The following basic assumptions were made regarding the development of the new Course of Study for Junior High General Science:

1. Science learnings during each semester build on the previous semester's work. New work builds upon a clearly defined sequence.

2. Junior High General Science content will be concerned with theoretical interpretation and an ability to conceptualize. Concern will be with broad concepts--with overview, rather than with a large body of purely descriptive facts.

3. Greater provision is to be made for laboratory work that provides experiences in the methods of science. This work must be more effectively and generally utilized if there is to be more realistic continuity with senior high school science.

4. A structured science sequence can be related to the daily life of pupils.

5. The subject matter is to be integrated. Biological and physical science concepts are to be applied simultaneously as they relate to the subject matter at hand.

6. Texts are resource materials and should be utilized as such. Probably no one text will adequately meet the needs of a given semester's work.

7. The continuity of the three-semester program will center about those aspects of content which are common to all the sciences, namely:

   Science is the discovery of new facts by means of observation and experimentation.

   Science is a method by which man attempts to define patterns describing the world.

   Science seeks order through classification schemes which illustrate the relationships in nature.

*Resource Units may be secured upon request from the Curriculum Branch, Division of Instructional Services.

Science seeks to answer such questions as:

Why do things happen as they do?
When do they happen?
Will they continue to happen?

Present described patterns of how the world works will be replaced by newer patterns as a result of continuing discovery and investigation.

Mathematics is an indispensable tool of the scientist.

Organization of Subject Matter Within the Classroom

Diversity of pupil interests and abilities represents a difficult problem to the teacher. How to meet the needs of differing ability groupings cannot be specifically stated here. This course of study does not differentiate subject matter into special or differing "brands" of science. The distinguishing characteristic is in the manner in which the teacher guides the pupils through a study of the basic content. It is the premise that there is only one kind of science; namely, that which relates to observation and the methods by which answers are sought. Every pupil can develop within his own level of attainment the capacity to exercise judgment based upon demonstrated fact and the capacity to understand rudimentary scientific principles through experimentation.

With respect to pupils of limited ability, the following guidelines are suggested:

1. In science instruction for slow learners, emphasize the relationship of science to everyday living.

2. Assign the same outlined units, but minimize greatly the requirements. Many of the experiments and demonstrations set up for the normal or above-average pupil may be used with a non-technical explanation.

3. Avoid theoretical approaches and the abstract. Use very concrete terms.

4. Remember that the slow learner has a very short attention span. There is greater need for a change of pace during each period.

5. Ascertain as early as possible the reading level of the pupils.

6. Since there is a notable lack of suitable reading material for very slow learners, provide substitute activities, such as construction work, drawings, and clay modeling for pupil reading where necessary.

7. Use "even more" audio-visual aids, but not those beyond the capacity of pupils to comprehend them.

8. Limit the number of demonstrations and spend more time in discussion of those used.

9. Perform only demonstrations which are easily analyzed.

10. Review frequently.

11. Limit the science vocabulary to only the more simple terms, and especially those more likely to be related to the experience of the pupil.

12. For vocabulary achievement, use:

    a. Vocabulary lists, blackboard, flannel board, pocket charts
    b. Daily or frequent spelling tests
    c. Word and meaning matching tests

13. Determine general achievement goals from the average ability level of the class.

SCIENCE INSTRUCTION AND THE PURPOSES OF GENERAL EDUCATION

The subject of general science is particularly well suited to the realization of Purposes of Education as developed in the Point of View.*

Intellectual Development

The study of general science for general education purposes is an intellectual pursuit whose purpose is to develop a more complete view of life in a scientifically oriented world culture. Science instruction stresses the methods used in scientific discovery. Accuracy of observation, collection and interpretation of data, evaluation of evidence gathered are skills that contribute to the ability to think critically. Critical thinking in making wise decisions is basic to an educated citizenry.

Civic Responsibility

Science instruction provides background concerning scientific development and its relation to society, thus preparing the citizen to understand the needs of scientific research and its demands upon public support. The effective use of natural resources is taught.

Economic Competency

The general science course emphasizes opportunities for careers in science and related areas. The educational background and the skills needed for successful employment are stressed.

Creativity

Scientific enterprise is a creative activity. General science encourages creativity through opportunity for experimentation.

Health

The normal functioning of the human body is studied in the general science course, thus providing a basis upon which good health practices may be understood and maintained.

*Point of View (1962 Revision. Los Angeles City Schools).

OBJECTIVES OF GENERAL SCIENCE

1. To develop an increasing awareness of and abiding interest in the various aspects of science that are a part of a pupil's surroundings; to stimulate scientific curiosity.

2. To grow in the ability to apply understanding of science principles and concepts to daily problems.

3. To grow in the ability to evaluate ideas critically; to ask critical and pertinent questions; to strive for intellectual honesty.

4. To grow in the ability to gather information from many sources, to remain open minded, and to make defensible judgments.

5. To develop scientific literacy with respect to reading and communication of facts and ideas.

6. To develop skills in discerning quantitative relationships and in making quantitative measurements encountered in science.

7. To grow in the ability to use observable and pertinent facts in making predictions; to develop the ability to generalize from seemingly unrelated facts.

8. To grow in the ability to organize materials according to classification schemes.

9. To grow in appreciation of the significance of scientific advances for human welfare and the contribution of scientists.

10. To grow in appreciation of the wise and effective use of our natural resources as well as the products of science and technology.

11. To grow in the development of interests in science leading to creative leisure-time activities and vocational opportunities.

12. To develop simple manipulative skills through the use of laboratory activities.

13. To appreciate the importance of science in support of our American way of life.

14. To appreciate the wonders and beauties of our natural surroundings and of the orderliness in the universe.

SEQUENCE OF PRESCRIBED CONTENT FOR GENERAL SCIENCE

	UNIT I	UNIT II	UNIT III
B8 **Science 1**	INTRODUCTION WAYS OF THE SCIENTIST What Is Science? Fields of Science Accuracy of Our Judgments Methods of the Scientist Tools of the Scientist	BUILDING BLOCKS OF THE UNIVERSE What Is Matter? General Properties of Matter States of Matter How Materials Are Put Together How Matter Can Be Changed Physical Changes Chemical Composition of Matter	AN INTRODUCTION TO LIVING THINGS Activities of Living Things Conditions of Life Building Blocks of Life Functions of Human Body
A8 **Science 2**	MAN AND SPACE What Our Universe Is Like What Our Solar System Is Like Satellites and Space Travel	OUR CHANGING EARTH Introduction to Geology The Earth's Crust Forces at Work on the Land Earth History	INTERRELATIONSHIPS OF LIVING THINGS Environment and Kinds of Living Things Structure and Function of Living Things Communities of Living Things
B9 or A9 **Science 3**	ENERGY The Nature of Energy Structural Relationships of Matter and Energy Energy and Wavelengths	METEOROLOGY Heat Energy and Weather Nature of the Atmosphere Weather Measurements and Their Use Greater Weather Patterns	FRONTIERS OF SCIENCE Oceanography Exploration of Space New Developments in Biology

SCIENCE 1 - B8

The B8 semester represents the first experience of the pupil with a specialized science course. Emphasis is to be placed upon orientation of the pupil to this broad subject field through the development of an overview of science in terms of its methods, of the interrelationships of its specialized branches, and of the unifying elements of its content. The basic unifying elements of science will be introduced in terms of the:

Methods of science
Basic units of matter
Basic units of living things
Relationship between living and non-living matter

As distinguished from the pupil's elementary school science experience, the junior high science course will place more emphasis upon:

An understanding of basic scientific concepts

An understanding of the methods of critical thinking by which these basic concepts can be applied to problems of one's environment.

The use of laboratory equipment and activities by which the methods of science can best be understood and appreciated

It is expected that the ideas of the first unit concerning "Ways of the Scientist" will permeate the entire junior high science experience.

Although it is acknowledged that a diversity of methods exists and that it remains for each teacher to select those experiences which best fit the needs and physical arrangement of a particular class, the basic concepts as outlined are to be developed.

Suggested time allocations for the units to be presented in Science 1 are:

Unit	Time Allocation
Introduction – Ways of the Scientist	3 – 4 weeks
Building Blocks of the Universe	3 – 4 weeks
An Introduction to Living Things	9 – 10 weeks

INTRODUCTION

Within this unit identification of the pupil with the scientist is sought in terms of understanding not only *what* the scientist studies, but also *how* he studies various problems.

The most effective way of realizing this understanding is to provide pupils with as many ways as possible to discover facts for themselves. Discovery does not have to entail elaborate procedures or experiments; it will occur every time an individual asks "why" and sets about the task of finding the answer through any means at hand.

The idea of science as a mysterious or magical process should be dispelled in favor of the view that science is a systematic way of thinking and doing which can be applied by everyone to daily problems.

Pupils bring an enthusiasm and curiosity to this subject as they do to few others. In a vague, uncertain way, they associate science with experiments, activity, astounding facts, and fun. Within the introductory unit and throughout the entire sequence, an attempt should be made to nurture and extend this promising regard for science.

CONCEPTS TO BE DEVELOPED

1. There are many specialized fields of science.
2. Scientific investigation arises from man's curiosity.
3. Scientists rely upon information advanced by other scientists.
4. Science utilizes information obtained through accurate observation and experimentation.
5. Systematic thinking is essential to scientific method. A problem is carefully identified, hypotheses are formed on the basis of existing facts, and hypotheses are tested by planned experiments.
6. Curiosity, clear thinking, and intellectual honesty are scientific attributes everyone should acquire.
7. Scientists, in applying experimental methods, carefully control conditions.
8. Scientific measurement requires an extension of the senses by the use of instruments.
9. Studies of science and mathematics are closely related. Mathematics is an important tool of the scientist.
10. The metric system of measurement is internationally used by scientists.
11. Reference books and periodicals are essential tools of the scientist.

OUTLINE OF CONTENT

A. WHAT IS SCIENCE?

B. WHAT ARE THE MAJOR FIELDS OF SCIENCE?

C. HOW ACCURATE ARE MANY OF OUR JUDGMENTS?

D. WHAT ARE THE METHODS OF THE SCIENTIST?

1. Scientists Learn by Reference to Authority
2. Scientists Learn by Observation
3. Scientists Learn by Trial and Error
4. Scientists Learn by Planned Experiments

E. WHAT ARE THE TOOLS OF THE SCIENTIST?

1. We Extend Our Senses by Use of Instruments
2. Measurement Techniques
   a. Introduction to the Metric System
   b. Use of the Ruler
   c. Use of Graduated Cylinders
   d. Use of the Beam Balance
   e. Use of Scientific Notation
3. The Library

INTRODUCTION

The study of matter is basic to the understanding of all natural phenomena. As a result of completing the unit, it is not assumed that pupils will attain a complete knowledge of the fundamental ideas presented. But it is hoped that, through continuing science experiences, a better understanding will gradually evolve. In effect, a working vocabulary is introduced that pupils will encounter in all subsequent units.

In providing an overview the teacher must be cautious to avoid losing pupils in a morass of facts and abstract ideas. It is definitely *not* the purpose of this unit to:

Present the mechanisms of chemical reactions in terms of electron transfer and configuration.

Belabor the nature of the periodic table.

Have pupils commit extensive formulas and equations to memory.

Specifically, the objectives of this unit are to develop:

Elementary understanding of the composition of matter in terms of molecules and atoms.

Understanding of the way in which matter is changed in terms of physical and chemical changes.

Elementary understanding of the use of chemical notation.

Class time is insufficient for all of the suggested learning experiences. Effective implementation of the unit requires the careful selection of a limited number of experiments and activities. It is not desirable to spend too much time developing any one topic.

The various suggestions are adaptable for securing pupil interest and participation either as a class or on a more individual basis.

This unit provides an excellent opportunity to point up safety practices. Carrying on laboratory activities requires vigilance on the part of the instructor to assure that safety is given first consideration by pupils. See page 57 for General Safety Precautions.

CONCEPTS TO BE DEVELOPED

1. Matter is anything that has weight and takes up space.

2. Matter exists in these states: liquid, solid, and gas.

3. All matter is made up of small particles called molecules.

4. The molecular theory can be used to explain many facts about matter.

5. Matter may undergo physical or chemical change. In a physical change, matter undergoes a change of appearance or a change of state. In a chemical change, matter is changed into one or more new substances.

6. Matter has both general and specific properties.

7. Matter is made up of single elements or combinations of several elements.

8. An atom is the smallest unit of an element. Atoms are the basic building blocks of all matter.

9. Atoms of all elements are made up of protons, neutrons, and electrons.

10. The differences between atoms of different elements are the result of differences in the number of protons and neutrons in the nucleus.

11. Atoms of elements can combine to form compounds. The smallest unit of a compound is a molecule.

12. The chemist can combine elements and compounds to form new substances.

13. The chemist uses symbols for atoms and formulas for molecules. Symbols and formulas are used in an equation form to express what happens during a chemical change.

14. The chemist can cause the decomposition of compounds (molecules) into simpler substances (molecules and atoms).

OUTLINE OF CONTENT

A. WHAT IS MATTER?

B. WHAT ARE THE GENERAL PROPERTIES OF MATTER?

1. All Matter Has Mass.
2. All Matter Takes up Space.
3. Matter Has the Characteristic of Impenetrability.
4. Matter Cannot Be Destroyed.

C. WHAT ARE THE STATES OF MATTER?

D. HOW ARE MATERIALS PUT TOGETHER? (THE MOLECULAR THEORY OF MATTER)

1. The Puzzling Nature of Matter.
2. The Molecular Theory.
   a. All matter is made up of small particles called molecules.
   b. There are spaces between molecules.
   c. Molecules are always moving.

E. HOW CAN MATTER BE CHANGED?

F. WHAT ARE PHYSICAL CHANGES?

1. Heating and Cooling Affect Matter.
2. Matter Undergoes Changes of State.

G. WHAT IS THE CHEMICAL COMPOSITION OF MATTER?

1. Classification of Materials.
2. The Nature of Elements.
   a. What are elements?
   b. Of what are elements composed?
   c. What is the chemist's shorthand way of writing atoms?
   d. How do elements differ from one another?

e. Why do elements differ from one another?

(1) Of what are atoms made?

(2) How can the atoms of more than 100 elements be arranged in an orderly sequence?

(a) Atomic number

(b) Atomic weight

3. The Nature of Compounds.

a. What are compounds?

b. How are atoms, molecules, elements, and compounds related?

c. What is the chemist's shorthand way of writing compounds?

(1) What are formulas?

(2) What are formula equations?

d. How do compounds differ from mixtures?

e. What is the chemist's way of describing a chemical change?

(1) How do substances combine?

(a) Elements combine to form compounds.

(b) Compounds combine to form new substances.

(2) How do substances decompose?

INTRODUCTION

A major goal of this unit is to develop in pupils an appreciation of the orderliness of the biological world in terms of structure, function, and the relationship of living things to their environment. There is a transition from the inorganic matter studied in Unit II to organic matter. The preceding unit was designed to develop an understanding of the basic nature and characteristics of matter. This understanding is essential to a study of the content of Unit III. Living things are matter and, as such, resemble non-living things. Methods of chemistry and physics are increasingly important to the biologist in his investigation of the characteristics which distinguish living from non-living matter.

In the study of living things, pupils will have the opportunity to integrate and apply their understanding of matter and the methods of the scientist.

The unit can be considered to have two phases. The first or introductory phase is intended to develop understandings of the general nature of living things in terms of their activities, chemical composition, structural organization, and relationship to environment. These basic understandings provide the background for study of the human body in the concluding phase of the unit.

CONCEPTS TO BE DEVELOPED

1. All living things have the same basic needs.
2. All living things are alike in the basic activities that they perform; they all have the same life processes.
3. All living things are influenced by the same conditions of environment.
4. All living things have the same unit structure; they are made up of cells that contain protoplasm.
5. Protoplasm carries on the life activities.
6. Basic elements and compounds of living things are the same.
7. Living things are interdependent.
8. Green plants manufacture food through the process of photosynthesis.
9. Photosynthesis is an energy-storing process.
10. All living things, except a few very special bacteria, depend directly or indirectly on photosynthesis for food.
11. The body is made up of different types of cells which are specialized as to structure and function, forming tissues, organs, and systems.
12. Foods supply body cells with the nutrients necessary for energy, growth, repair, and maintenance of functions.
13. Digestion is a process involving chemical changes, whereby complex molecules of nutrients are broken down into a soluble form that can be used by the body.
14. The blood supplies cells with essential materials and removes wastes from them; these exchanges occur at capillary sites by diffusion.
15. The pumping action of the heart keeps blood flowing in the vessels of the circulatory system.
16. Breathing is a mechanical process in which air enters and leaves the lungs as a result of pressure changes within the chest cavity.
17. Gaseous exchange of carbon dioxide and oxygen between blood and air occurs in the air sacs of the lungs by diffusion.
18. Respiration is an energy-yielding process.
19. The skeleton supports the body, protects its vital organs, and makes movements possible.
20. All body movements are brought about by contraction of muscles

CONCEPTS TO BE DEVELOPED

21. Nerve cells are the functional units of the nervous system.
22. The nervous system controls body activities.
23. The nervous system enables the body to react to stimuli in the environment.
24. An individual's behavior can be changed through learning.
25. Our characteristics are either inherited or acquired.
26. Acquired characteristics cannot be inherited.
27. Inherited characteristics are passed from parent to offspring through the genes located in chromosomes.
28. Both environment and heredity are important in the development of living things.
29. The way in which the body responds to stimuli is the result of heredity and acquired behavior.

OUTLINE OF CONTENT

A. WHAT ARE THE ACTIVITIES OF LIVING THINGS?

B. WHAT ARE THE CONDITIONS OF LIFE? (THE ENVIRONMENT OF LIFE)

C. WHAT ARE THE BUILDING BLOCKS OF LIFE?

1. The Microscope – Observing Building Blocks of Life.
2. What Does the Microscope Reveal About the Structure of Living Things?
3. What Are Cells Made of?
4. The Chemical Composition of Living Things.
5. Energy Relations of Life.

D. HOW DOES THE HUMAN BODY FUNCTION?

1. Man's Place Among Living Things.
2. How the Body Uses Food.
   a. What nutrients do cells require?
   b. How does your body digest food?
3. The Body's Transport System.
4. How and Why We Breathe.
5. Movement of the Body.
6. How and Why We Act the Way We Do.
   a. Nervous control of body activities
   b. Receptors – tuning into our environment
   c. Behavior
      (1) How are characteristics inherited?
      (2) What is the mechanism of heredity?
      (3) What is behavior?
      (4) How can behavior be changed?
      (5) How do we learn?

SCIENCE 2 - A8

Science 2 builds upon the background that the pupil has developed through experiences carried on in the Science 1 course. The units in Science 2 develop in depth an understanding of the universe and man's place in it; the changing earth and causes of change; and finally the survival of living things upon the earth and their interdependence.

The emphasis upon opportunities for pupils to discover facts for themselves wherever possible is continued as a vital part of this course.

Suggested time allocations for the units to be presented in Science 2 are:

Unit	Time Allocation
Man and Space	6 weeks
Our Changing Earth	5 – 6 weeks
Interrelationships of Living Things	7 – 8 weeks

INTRODUCTION

The study of astronomy is an important part of the study of the history of science. Within its content, which has directly and indirectly influenced man's life for a period of 4000 years, is to be found the evolution of scientific method. In perhaps no other field can we communicate so well to our pupils an understanding and appreciation of how basic science concepts are continuously extended and modified. Through the study of astronomy, pupils can also clearly recognize man's progress from superstition to reason by the use of observation and experimentation.

The astronomy unit affords a splendid opportunity to reveal the integrated nature of modern science. It involves the major science disciplines of physics, chemistry, and biology. In the astronomy unit, a primary objective should be the implementation of the basic concepts developed during the preceding semester. Opportunity exists for:

Extending understanding of the methods of the scientist, the basic units of matter, and the basic nature of living things

Utilizing the discovery approach to subject matter

Appreciating the interrelationships of fields of science

Extending the idea of order in nature through classification schemes and universal laws.

How these objectives are attained will depend upon the individual teacher's unique presentation. The concept that science is a "thinking habit" rather than just a collection of facts will not arise spontaneously. It will result only from each teacher's careful planning of activities and procedures directed toward the development of critical thinking.

Answers to the following questions will be sought in this unit:

What is the universe? How vast is it?
What are the means of studying it?
What are some of the basic laws of the universe?
What is our relationship to the rest of the universe?
Can man survive in space?
To what extent has man been able to explore space?
What does the beauty and order of the universe mean to us?

CONCEPTS TO BE DEVELOPED

1. Constellations are apparent groupings of stars.
2. Stars are classified according to their brightness or magnitude.
3. Location on earth, time of day, and season of the year determine which stars can be seen.
4. A light year is the distance that light travels in one year at the rate of 186,000 miles per second.
5. The astronomer uses specialized tools, such as mathematics, the telescope, and the spectroscope, to study the universe.
6. Energy is produced in stars as the result of the conversion of matter to energy.
7. Our sun is a typical star with respect to size, brightness, and surface temperature.
8. Distances in space seem vast when compared with distances on earth.
9. Our sun is located in the Milky Way Galaxy.
10. There are millions of galaxies.
11. Present patterns of the universe may be replaced by newer ones as the result of continuing observation and discovery.
12. The solar system is made up of the sun and of all the heavenly bodies which revolve around it.
13. The apparent motion of the sun, moon, planets, and stars across the sky is a result of the rotation and revolution of the earth.
14. Science has proceeded from a purely descriptive phase based on logic alone to a quantitative phase based on observation and experimentation.
15. Gravitation, which is the force of attraction between any two bodies, depends upon their masses and the distance separating them.
16. Gravity is the attractive force which pulls a mass toward the center of the earth.
17. An object at rest will remain at rest, and an object in motion will remain in motion, unless some force acts on the object.
18. At a given point on the earth's surface, all bodies fall with a constant acceleration or change of speed which is independent of the mass or size of the body if air resistance is disregarded.
19. Movement of all bodies in the solar system is a result of gravitational attraction and inertia.

CONCEPTS TO BE DEVELOPED

20. Conditions on earth which support life are not the same as those throughout the solar system.

21. The moon's appearance changes as different amounts of light are reflected from its surface.

22. Phases of the moon, eclipses, and tides are the result of motions of the earth, moon, and sun.

23. Artificial satellites and space vehicles move in accordance with the laws that govern celestial bodies.

24. Rockets and satellites are adding to man's understanding of his planet home and of the universe as well.

25. Man's ability to survive in space requires that he be provided with an artificial environment that simulates conditions on earth.

OUTLINE OF CONTENT

UNIT I. MAN AND SPACE

A. OUR UNIVERSE

1. What Can We Learn About Stars?

a. What do we know about constellations?

b. How do astronomers learn about the universe?

(1) What unit is used to measure sky distances

(2) How are sky distances measured?

(3) How does a telescope work?

(4) How do astronomers use the spectroscope?

c. What is a typical star like?

(1) What is our sun made of?

(2) Why does the sun shine?

(3) How hot is our sun?

(4) What are some surface features of the sun?

(5) How big is our sun?

2. What Are Galaxies?

a. What is our galaxy like?

b. What is happening to the universe?

B. OUR SOLAR SYSTEM

1. What Is the General Nature of the Solar System?

a. Which are the members of the solar system?

b. How have ideas regarding the solar system changed?

c. What are some basic facts about our solar system?

OUTLINE OF CONTENT

d. What causes bodies to move in space as they do?

(1) The work of Kepler

(2) The work of Galileo

(3) The work of Newton

(a) What is inertia?

(b) What is gravity?

(c) Why do planets stay in orbit?

2. What Theories Exist Regarding Planetary Environments and the Possibility of Life?

C. SATELLITES AND SPACE TRAVEL

1. What Is Our Natural Satellite Like?

a. What is the physical nature of the moon?

b. How do motions of the moon affect the earth?

(1) What are the motions of the moon?

(2) Why does the moon change appearance?

(3) What are eclipses?

(4) What causes the tides?

2. What Are Artificial Satellites Like?

a. How have satellites added to our knowledge?

b. What is the principle of the rocket engine?

c. What are the mechanics of space flight?

d. How can man survive in space?

INTRODUCTION

It is the purpose of this unit to study the dramatic evolution of our landscape. Understanding and appreciation of the mechanisms of geologic change are not readily acquired. Those processes which contribute to the greatest modification and transformation of the earth's surface cannot be detected by the casual observer. In fact, most changes in the landscape are unnoticeable during the span of human life.

Many basic questions continue to baffle the geologist and to pique his curiosity, such as –

What is the origin of the earth?

What is the nature of the earth's interior?

What are the nature and cause of crustal movements?

What are the origin and nature of the environmental changes which have modified life on the earth?

To gain insight into the nature of these problems as well as general understanding of the fundamental aspects of geology, it will be necessary for pupils to apply the physical and chemical concepts and biological knowledge gained in previous units.

- Despite classroom limitations on presentation of a field subject, pupil understanding can be increased by making use of the striking examples of geologic formations and changes in the vicinity of Los Angeles. Within the classroom, the teacher can capitalize upon the geologic "encounters" of our pupils not only with the local terrain but also with the wonders preserved in the national parks. It is our task to bring geology into the classroom in order that we may assist pupils to enjoy more directly this study out of doors.

CONCEPTS TO BE DEVELOPED

1. Geologic change is a continuous process; the surface of the earth is constantly changing.

2. Geologic change is predominantly a very slow process which is not ordinarily perceived.

3. The greatest changes in the earth's surface are the result of slowly working geologic processes.

4. Some processes are at work wearing down the land; others are helping to build it up.

5. Available data allow the scientist to evaluate the many theories which have been advanced to explain the origin of the earth.

6. The age of the earth and the nature of its interior have been investigated by specialized tools which extend man's senses.

7. The earth's surface is composed of rocks, minerals, and soil.

8. The rocks of the earth's crust are composed of minerals and mixtures of compounds and elements.

9. The earth's rock minerals are all derived from molten materials which have solidified and undergone other natural changes.

10. Rocks may be formed by:

    the cooling and solidifying of molten material
    the compacting and cementing of sediments

11. Rocks may be metamorphosed or changed by heat and pressure.

12. Weathering is the natural disintegration and decomposition of rocks and minerals by physical and chemical processes; it is the first step in soil formation.

13. Soil is a complex mixture of living and non-living things.

14 Erosion is the process by which rocks are broken down and moved by the action of running water, ice, shore currents, and the wind.

15. Topsoil is eroded when it is exposed to the agents of erosion or especially unprotected sloping surfaces.

16. When elevations or depressions are created upon the surface of the earth, the elevations are usually attacked by the agents of erosion and the materials are carried to the depressions.

17. Land forms generally have a regular cycle: initial, youth, maturity, and old age.

CONCEPTS TO BE DEVELOPED

18. Earthquakes are produced by sudden fracturing of rock strata along faults in areas of crustal stress.

19. Changes may occur within the inside of the earth to cause land mases to rise or sink and cause parts of the earth's surface to be folded into mountains.

20. Changing conditions on the earth in the past have been interpreted in relation to changing conditions on the earth today.

21. The history of the earth is revealed in the fossil records of life, in the relative positions of rock strata, in the structural deformation of rock strata, and in the radioactive decay of minerals.

22. Fossils dated by the rocks in which they are found reveal portions of the actual story of life's past changes.

23. Geologists are more interested in the sequence of events than in the exact dates of their occurrence.

OUTLINE OF CONTENT

UNIT II. OUR CHANGING EARTH

A. INTRODUCTION

1. What Is Geology?
2. What Are Some Theories As to the Origin of the Earth?
3. What Is the Physical Nature of the Earth?
   a. What are the zones of the earth?
   b. What is known about the earth's interior?

B. THE EARTH'S CRUST

1. What Is the Composition of the Earth's Crust?
2. What Is the Nature of Minerals?
   a. How are minerals identified?
   b. What are some important uses of minerals?
3. What Kinds of Rocks Make up the Earth's Surface?

C. FORCES AT WORK ON THE LAND

1. What Forces Wear Away the Land?
   a. What is the purpose of national parks?
   b. How is the earth's rocky crust changed by weathering?
      (1) What is the nature of mechanical and chemical weathering?
      (2) What is soil?
   c. How is the earth's surface changed by erosion?
      (1) What is stream erosion ?
         (a) What are the mechanics of stream cutting?
         (b) What is the life cycle of a stream?
         (c) What land forms are produced by streams?
      (2) What is marine erosion?
      (3) What is glacial erosion?

OUTLINE OF CONTENT

2. What Forces Build up the Land?

   a. What do we know about crustal movements?

      (1) What is the origin of crustal movements?

      (2) What are faults and earthquakes?

      (3) What crustal movements produce mountains?

   b. How does vulcanism build up the land?

D. THE GEOLOGIC HISTORY OF THE EARTH

1. How Do Geologists Determine the Physical History of the Earth?

2. What Do We Know About Fossils?

3. What Is the Geologist's Timetable?

INTRODUCTION

It is the purpose of this unit to explore the ultimate problem of all living things – that of surviving conditions on an ever-changing earth.

To consider this problem, pupils will obtain an overview of life in terms of its:

Diversity in place and time

Variety of structure and function

Web of interdependence with regard to the interrelations of living things with each other and with their physical environment

Ability to adapt to the unique conditions of its environment

To understand biology as a unified whole, pupils will need to apply their curiosity to the direct observation and examination of living things outside as well as inside of the classroom.

CONCEPTS TO BE DEVELOPED

1. All living things are alike in the basic activities that they perform; they all have the same life processes.

2. All living things are influenced by the same conditions of environment.

3. Environmental conditions determine the distribution of living things.

4. To survive, living things must adapt to environment.

5. There is a great diversity of living things.

6. Living things are classified according to similarity of structure.

7. Living things are classified as microorganisms, plants, or animals.

8. Hereditary characteristics in all organisms are determined by genes which are carried in the chromosomes.

9. Microorganisms, plants, and animals have specialized structures for carrying on life functions.

10. An energy-matter cycle exists in nature in terms of the relationships between producer, consumer, and decomposer organisms.

11. Plants which contain chlorophyll are the primary producers of food for the living world.

12. A balance in nature is maintained through the interrelations of plants and animals with each other and with their physical environment.

13. Man disturbs balance in nature.

OUTLINE OF CONTENT

UNIT III. INTERRELATIONSHIPS OF LIVING THINGS

A. ENVIRONMENT

1. What Is Environment?
2. Habitats – How Do Environments Vary?
3. What Is Meant by Adaptation to Environment?
4. How Are Living Things Classified?
5. How Have Living Things Changed Through Geologic Time?

B. VARIETY OF STRUCTURE AND FUNCTION OF LIVING THINGS

1. Microorganism – What Can We Learn About Microorganisms?
   a. What are microorganisms?
   b. Where are microorganisms found?
   c. How are microorganisms important in plant and animal communities?
2. Plants – The Structure and Function of Seed Plants.
   a. What is the structure of a typical seed plant?
   b. What structure and function do each of the following have?
      (1) Roots
      (2) Stems
      (3) Leaves
   c. How do plants reproduce and grow?
      (1) What are the structure and function of flowers?
      (2) What are the structure and function of seeds?
   d. How do plants respond to environment?
3. Animals – The Study of a Single Animal Group: Insects
   a. What are insects?
   b. What structural and behavioral adaptations do insects have?
   c. What can we learn about the life histories of insects?

OUTLINE OF CONTENT

C. COMMUNITIES OF LIVING THINGS

1. What Working Relationships Exist Within Communities of Living Things?
2. What Communities of Living Things Exist Locally?
3. What Can We Learn About Seashore Communities?
   a. What is the nature of the marine environment?
   b. What marine intertidal associations exist locally?

SCIENCE 3 - B9 or A9

In Science 1 and 2, the nature of the sun as the ultimate source of the earth's usable energy was considered. Science 3 builds upon that generalization and utilizes the concept of energy as its underlying theme.

Unit I begins with an explanation of mechanical energy in terms of momentum, force, and work. This development leads to a study of chemical, nuclear, electrical, heat, and radiant forms of energy. Since the radiant heat from the sun is the prime mover of the earth's atmosphere, the transition from the study of heat energy in Unit I to Unit II, which concerns meteorology, can be accomplished smoothly. The water cycle, the effects of storms on coastlines, and the adverse effects of weather on ocean shipping or fishing fleets all may provide direction or call attention to the study of oceanography. Certainly, the study of the layers of the earth's atmosphere can introduce pupils to space exploration. Thus, the transition from Unit II to Unit III, Frontiers of Science, is also logical.

Units concerning ***light*** and ***sound*** have been omitted because adequate coverage of all fields of energy is not possible in a single semester. In addition, some aspects of these topics were introduced in Science 1 and 2. However, the section on wave lengths in Unit I offers ample opportunity to provide further study of light and sound if the teacher believes that it is desirable at this time.

With regard to energy as the conceptual theme (the "grand idea") of Science 3, it should be noted that "Conceptual themes in science are *not* simple rephrasings of 'areas of subject matter.' While some conceptual themes appear to emphasize one subject matter area more than others, a more significant characteristic of conceptual themes is that they cut across conventional subject-matter boundaries. This reflects the precept that scientific knowledge is broad and integrated, not a series of discrete academic principles."[1]

Although little mention is made of the study of biological activities in this course, the teacher should note that life is a continuous process involving transfer and transformation of matter and energy; that biological activity is a function of chemical and physical changes; and that the energy required by living organisms is derived ultimately from the sun. The degree to which the high school teacher is able to teach modern concepts in biology will be determined by the strength of pupil background in matter and energy developed in Science 3

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[1] *Conceptual Themes as a Framework for Science Education*, Science Curriculum Improvement Study, Robert Karplus, Director, Berkeley, California, 1967, p. 1.

Pupil activities and independent study should be encouraged whenever possible. To observe an insect closely, to draw a graph, to operate a microscope, to observe a chemical reaction are examples of experiences which help pupils gain genuine understanding of science.

Suggested time allocations for the units to be presented in Science 3 are:

Unit	Time Allocation
Energy	10 – 12 weeks
Meteorology	3 – 4 weeks
Frontiers of Science	3 – 4 weeks

INTRODUCTION

Energy is fundamental to the explanation of the nature and behavior of all forms of matter. It may be encountered everywhere. But what is energy? What is meant by conservation of energy? Scientists tell us that "the Principle of Conservation of Energy is probably the most important single generalization in the whole of science."[1] What kinds and forms of energy exist? What is meant by transformation of energy? How are matter and energy relative? How may energy be transferred through immaterial space?

Historically, the answers to these questions have emerged slowly, particularly those which pertain to an understanding of the Principle of Conservation of Energy. Part of this slow emergence was a result of the indiscriminate and interchangeable use of the terms ***force***, ***momentum***, ***work***, and ***energy*** by early scientists. ***Work***, a simpler concept than that of ***energy***, was identified long before the latter. But ***momentum***, an even older concept, became confused with ***work*** during the 17th and early 18th centuries. Leading scientists like Newton, Descartes, Kepler, D'Alembert, and Leibnitz were involved directly or indirectly in this confusion. To understand the nature of energy, then, it is necessary to develop first an understanding of momentum, a most important concept in its own right.

Pupils began to learn basic chemical terms in Science 1 and have continued to study them. No attempt was made, however, to study the mechanism of chemical or nuclear reactions. It is the purpose of this unit to explore this topic in greater depth. In the study of this mechanism, teacher and pupil activities should be designed to "uncover" the following: (1) that matter has a regularity of form and can be classified; (2) that energy transformations always accompany changes in this regularity; (3) that extremely large energy changes occur when the nuclear level of matter is disturbed.

Wave motions are intimately associated with mechanical, electrical, thermal, and electromagnetic forms of energy. Radio waves, X-ray waves, electrical waves on power and telephone lines, and waves of electrochemical reaction along nerve fibers are of tremendous importance to our lives. What are these waves? The duality of the particle and wave behavior of light clouded the understanding of the wave nature of light for a long time, and some aspects of this subject still remain open to question. What is the nature of the association between waves, matter, and energy?

It is the intent of this unit to examine some of the important ideas and characteristics of energy.

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[1]Francis T. Bonner, and Melba Phillips, *Principles of Physical Science.* (Reading, Mass.: Addison-Wesley, 1957), p. 195.

CONCEPTS TO BE DEVELOPED

1. The energy of the universe is constant.
2. Energy can be transformed but not created nor destroyed.
3. Energy may be changed into many different forms.
4. Capacity to perform work is generally what is meant by energy.
5. Energy is involved when the internal order of matter is disturbed.
6. Matter exhibits a regularity of form.
7. In ordinary chemical reactions, matter can be neither created nor destroyed.
8. The valance concept attempts to express the relative capacities of atoms for combination with one another.
9. Acids, bases, and salts, when dissolved in water, break into charged particles called ions.
10. Greater energies are involved in a disturbance of matter at the nuclear level than at the molecular level.
11. The equation $E=mc^2$ expresses the general principle of the conservation of mass energy.
12. Nuclear energy is making many important contributions toward solving some of man's problems.
13. Radioactive fallout presents biological hazards to mankind.
14. A wave is a traveling disturbance of a medium from its normal condition.
15. Wave motions are usually described in terms of the common characteristics of frequency, wave length, and amplitude.
16. The differences in frequency of the various types of electromagnetic waves are responsible for their differing characteristics.
17. The transfer of energy through immaterial space is known as radiation.
18. Matter which gains or loses electrons acquires an electrical charge.
19. Electricity is a fundamental characteristic of the universe, and it is manifest all the way from interstellar space to the nucleus of the atom.
20. An electric current is a flow of electric charge.
21. There must be a difference of electric potential between two points in a circuit if a current is to flow.

CONCEPTS TO BE DEVELOPED

22. Magnetism is a fundamental property exhibited in all forms of matter.

23. Magnetic fields may be produced by motion of electric charges.

24. Whenever there is a change in the strength of a magnetic field surrounding a conductor, an electromotive force is induced in the conductor.

25. Heat energy is the energy of motion of molecules.

26. All other forms of energy may be converted into heat.

27. Heat is a form of energy that flows between two bodies which are at different temperatures.

28. The temperature of a body depends upon the average kinetic energy of the molecules in the body.

29. Latent heat is the name given to that amount of heat which changes the state of a body without changing its temperature.

OUTLINE OF CONTENT

A. THE NATURE OF ENERGY

1. Momentum and Force
2. Work and Simple Machines
3. Potential and Kinetic Energy
4. Specific Forms of Energy
5. Generalizations

B. STRUCTURAL RELATIONSHIP OF MATTER AND ENERGY

1. Review of Elements and Compounds
2. Solutions and Crystallization
3. The Periodic Table and Orderly Elements
4. Combining Atoms
5. The Power of the Atom

C. ENERGY AND WAVE LENGTHS

1. The Nature of Waves
2. Wave Lengths and Forms of Energy
3. Electrical Energy
4. Heat Energy

INTRODUCTION

What is the relationship between energy, the atmosphere, and man? A description of a bioclimatologist will help to answer one part of this question. Bioclimatologists are a new kind of scientist. These ecological specialists study the environmental effects of weather and climate on living organisms. They are concerned with the importance of air to physical and life processes and with the accumulative effects of weather, climate, and seasonal changes on biotic communities. During Science 1 and 2, pupils have developed some understanding of the atmosphere as a part of the natural environment in which we live.

The purpose of this unit is to continue to increase this understanding through developing a knowledge of energy. Are the factors of heat, the water cycle, the composition of the atmosphere, precipitation, and the motion of air masses a part of an energy cycle that is related to the sun? As far as scientists know at this time, no other planet has just the exact gaseous mixture which can support life; nor does any other planet have the heat and moisture conditions necessary to support similar forms of life. The states of the atmosphere and the controls to which they are subject are all vital to man's existence. Can man predict and control the changes in weather that affect his health, comfort, and ways of making a living?

CONCEPTS TO BE DEVELOPED

1. Weather is the condition of the atmosphere at a certain place and time.

2. Weather phenomena involve vast energy changes in terms of heating the atmosphere and of the movement of air.

3. The three major elements responsible for the circulation of the earth's atmosphere are the heat of the sun, rotation of the earth, and friction between the earth's irregular surface and the air itself.

4. Atmospheric capacity for absorbing and retaining moisture is regulated by temperature.

5. If air is cooled below its saturation point, condensation will occur, resulting in clouds and precipitation.

6. Natural processes, such as the carbon dioxide and nitrogen cycles, help to maintain the proper balance of life-supporting gases.

7. Atmospheric pressure or the weight of the air per unit area, tends to be high in the higher latitudes near the poles and low in the lower latitudes near the equator because cold air is heavier than warm air.

8. Air masses are formed when the atmosphere is stagnant over an area for a limited time.

9. When two different air masses meet near a low-pressure area, they may form a front. This is a sloping surface separating colder, heavier air below from the warmer, lighter air above.

10. At high altitudes, the mixing of warm equatorial air with cold polar air creates systems of high speed winds that appear to have a great effect on the weather pattern.

11. Weather forecasts are made up from collections of weather data, followed by interpretations of weather maps, in which forecasters consider previous experience under similar conditions and the laws governing air movement.

12. Climate is the average weather in a locality over a number of years.

13. Insolation is governed mainly by latitude, which determines the angle of the sun's rays and the length of day at a particular place.

14. Insolation is the primary factor in the control of climate.

15. The major consideration in climatic classification is temperature.

CONCEPTS TO BE DEVELOPED

16. Oceans are the great thermostats of the maritime climates, while the continental climates are controlled more directly by the sun.

17. The tilt of the earth on its axis and the revolution of the earth around the sun are the primary causes of seasonal change.

OUTLINE OF CONTENT

A. HEAT ENERGY AND WEATHER

1. Air Movement
2. The Water Cycle

B. THE NATURE OF THE ATMOSPHERE

1. Composition of the Air
2. The Weight of the Atmosphere
3. Layers of the Atmosphere

C. WEATHER MEASUREMENTS AND THEIR USE

1. Instruments and Weather Factors
2. Movements of Air Masses
3. Weather Maps and Forecasting

D. GREATER WEATHER PATTERNS

1. Climates
2. Seasons

INTRODUCTION

Suggested topics for Unit III are Oceanography, Exploration of Space, and New Developments in Biology. Only Oceanography has been developed, although suggested learning experiences have not been included. However, some suggested topics for discussion, activities, demonstrations, and references are provided in the resource unit.

Using the presentation on Oceanography as a model, teachers can develop similar sections with pupils for the other topics.

The major goals of this unit are to:

Illustrate the integrated nature of the frontier sciences.

Disclose the nature of the research activities necessary for the continuing advancement of mankind's knowledge of his environment.

Reveal the career opportunities available in new fields of science.

Develop an appreciation of the library and its facilities and of books as powerful tools of science.

Encourage extensive use of periodicals.

Teach pupils how to prepare written and oral reports regarding science.

Library projects are particularly appropriate during this unit. Advancements in the frontier sciences are so current that information about discoveries and progress in these fields can be obtained only from recent periodicals and similar publications. Even the latest editions of junior high school science texts do not contain the information available in periodical literature.

Of all the new fields, perhaps oceanography best reveals the need for the combined efforts of many different specialists in conquering the perplexing and complex problems of a continually changing world. Oceanographic research is international in scope and requires the unified efforts of chemists, physicists, meteorologists, mathematicians, geologists, and biologists having specialized training.

The teacher may allocate the time for Unit III in several ways. He may wish to devote the entire three to four weeks to the study of a single topic, such as oceanography; he may spend one week on each of the three topics; or he may spend two weeks on each of two topics. The final decision will be based upon teacher-pupil planning.

CONCEPTS TO BE DEVELOPED FOR OCEANOGRAPHY

1. Some scientists believe that the oceans were the birthplace of life itself.

2. World weather, climate, precipitation, and the carbon dioxide content of the atmosphere are all influenced by the ocean.

3. The contour of the ocean floor affects oceanic circulation as well as distribution of marine organisms.

4. Differences in temperature, salinity, winds, and rotation of the earth result in currents.

5. Shifting patterns of equatorial and polar currents cause a fluctuation of the surface temperature of oceans.

6. Waves result from the friction produced when wind acts upon water.

7. Tides are the periodic rise and fall of the ocean's water, produced by the attraction of the moon and the sun.

8. Waves and tides are a potential source of power.

9. Wide varieties of life exist in the sea because sea life has a greater space in which to grow and more favorable physical and chemical conditions than any other known environment.

10. Accumulating evidence indicates that, acre for acre the world over, the sea may be more productive than the land in both minerals and food stuffs.

11. The knowledge obtained through the study of oceanography may help to solve the potential food shortage of a rapidly expanding world population.

Conceptual Themes as a Framework for Science Education, Sunnyvale, Calif.: Junior and Senior High School Science Teachers, 1961.

OUTLINE OF CONTENT FOR OCEANOGRAPHY

A. OCEANOGRAPHY (Sample Development)

1. In the Beginning
2. Exploring the Ocean
3. The Sea Floor
4. Waves, Currents, and Tides
5. Sea Life
6. Mineral Resources From the Sea
7. The Ocean and Mankind

B. EXPLORATION OF SPACE (To be developed according to pupil interest)

C. NEW DEVELOPMENTS IN BIOLOGY (To be developed according to pupil interest)

EVALUATION

Evaluation of pupil achievement is used to determine attainment of:

Underlying goals and skills
Understanding and acquisition of basic concepts

The relative importance of these two aspects of evaluation cannot be simply stated because of the varied situations and abilities encountered in the classroom. Both are important, however, and it is possible to offer guidelines for their measurement.

Evaluation of Underlying Goals

Criteria for this type of continuous evaluation can be stated in terms of (1) a pupil's behavior, and (2) the opportunity he has had to develop skills as a result of the instructional program.

1. Criteria for evaluating behavior as it relates to the goals of science program. Does the pupil:
   a. Observe kinds, parts, and functions?
   b. Order and relate things in terms of sequence, size, color, use, or general characteristics?
   c. Make exceptions; find discrepancies?
   d. Use his knowledge to make predictions?
   e. Observe and talk with understanding about the laws of nature?
   f. Ask critical and pertinent questions?
   g. Seek books and charts?
   h. Gather revelant information from many sources, correlate it, and make defensible conclusions?
2. Criteria for evaluating the classroom development of skills. Does the pupil:
   a. Identify problems and unanswered questions?
   b. Formulate hypotheses?
   c. Design experiments to test hypotheses?
   d. Think and express himself in quantitative terms?
   e. Interpret data, graphs, tables and charts?
   f. Perform experiments that provide experience in making accurate observations?
   g. Record observations in an organized manner?
   h. Use a variety of scientific methods in performing experiments?
   i. Locate materials other than books?

j. Locate source materials in the library?

k. Read textbook assignments with understanding of content?

Evaluation of Understanding and Acquisition of Basic Concepts

Teacher-made and standardized tests are used to perform evaluations of this type. Tests must be constructed to measure pupil abilities developed through the instructional program. If we are trying to measure the ability to think critically, a test based on the ability to repeat information is not an appropriate evaluation device.

A test item may be in either of the following forms:

Objective: This form includes multiple choice, true or false, completion, matching, identification (e.g., parts of a diagram), or proper sequence (e.g., place planets in proper order from sun).

Essay: This technique requires a pupil to recall, select, organize and defend his knowledge in creating a desired response. Properly constructed and graded, it is an excellent indication of what "goes on" in a pupil's mind.

In the preparation of an essay test, the teachers should:

Make questions specific; they should enable the pupil to provide a definite answer.

Clarify scoring procedure by dividing test item into specific parts and by indicating credit to be allowed for various parts.

As a preliminary and guide to scoring, prepare an outline of points expected to be covered in pupils' answers.

Be certain that pupils who cannot express themselves well in writing are not penalized.

Be selective in the type of questions used; the questions should have validity -- they should measure what the teacher wants them to measure.

Both objective and essay test forms are useful. Apart from the quick-scoring aspect of the objective form, both require subjective judgment in their construction and can be used to evaluate effectively a pupil's understanding and acquisition of basic content.

However, the form of a test item is secondary to the construction of the item in terms of the ability being tested. Test items classified by the ability to be measured may arbitrarily be divided into the following types:

I. To measure the ability to repeat or use information and meanings

II. To measure the ability to apply key principles

III. To measure the ability to apply critical thinking

Test items designed to measure specific abilities are illustrated below:

Type I. To measure the ability to repeat or use information and meanings.

Essay

1. Why is astronomy classified as a physical science rather than as a natural science?
2. What is meant by the statement, "Scientists learn by reference to authority."?

Objective

Directions: Choose from the list of possible answers the one which is most correct. Write the number of the correct one in blank space to the left.

_____ 1. Ecology is the study of the
   a. economic value of living things
   b. heredity of living things
   c. history of living things
   d. relationship of living things to their environment

_____ 2. A steel rod is .24 cms in diameter. A glass slide is .30 cms in thickness. Approximately how many times thicker is the slide than the diameter of the rod?
   a. 1.2
   b. 12.2
   c. .070
   d. .122

Type II. To measure the ability to apply key principles.

Essay

1. John prepared an aquarium by first carefully cleaning a 10-gallon tank with salt solution and by putting a few inches of fine washed sand on the floor of the tank. He rooted several stalks of weed (elodea) taken from a pool and then filled the aquarium with tap water. After waiting a week, he stocked the aquarium with ten 1-inch goldfish and three snails. The aquarium was then left in a corner of the room. After a month, the water had not become foul. Plants and animals were in good condition. Without moving the aquarium, he sealed a glass top on it.

   What prediction, if any, can be made concerning the condition of the aquarium after a period of several months? If you believe a definite prediction can be made, do so and then state your reasons. If you are unable to make a prediction for ***any*** reason, state what your reasons are.*

2. Describe a procedure to explain how water rises in plants.

3. Describe a procedure to show that water is not a simple substance.

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*Adapted from B. S. Bloom, ed., *Taxonomy of Educational Objectives*. New York: Longmans, Green and Co., 1956.

Objective

Directions: Choose from the list of possible answers the one which is most correct. Check the blank space in front of the item which best completes the sentence.

_____ 1. "I have always tried to keep my mind free so as to give up any hypothesis, however much I liked it, as soon as all available facts are shown to be opposed to it." This statement would tend to show that the man who made it
   a. lacked conviction
   b. had little or no insight
   c. possessed the characteristic of intellectual honesty
   d. would be easily swayed by propaganda

_____ 2. When a person speaks of life, he has certain ideas in mind. The power of moving about is associated with living things, but all living things do not possess this ability. Plants are alive, but many of them do not move about. Crystals grow; therefore, growth cannot be a characteristic which is restricted to living things. Many people consider respiration to be the best distinction, but respiration is oxidation or burning, a process which would also include the burning of oil or wood. The major problem presented in the above paragraph is
   a. Do all living things move about?
   b. Is growth restricted to living things?
   c. Do all people interpret life in the same way?
   d. What is life?
   e. Can any except non-living things be oxidized?

Type III. To measure the ability to apply critical thinking.

Essay

Directions: A hypothesis is a statement that may or may not be true. Make an outline of the procedure that you would use to test a hypothesis. List the experiments that would be necessary to learn whether it was true or not true. For your hypothesis choose any statement from the five listed below:

1. Ashes on snow makes it melt faster.
2. Cut flowers will not fade as rapidly if an aspirin tablet is dissolved in the water in which they are kept.
3. Hot water freezes sooner than cold water.
4. Dishonesty shows itself in a person's eyes.
5. Toads cause warts.

Objective*

A boy found an opossum in a hollow trunk of a tree. As he approached the animal, he noticed there was no response. The animal appeared to be dead. He picked the animal

*Adapted from Instructional Guide, *Life Science I*, Los Angeles City Schools, Publication No. SC-565, 1958.

up by its tail. He noticed the tail coil slightly around his finger. This made him wonder if the animal was really dead. He took the animal home and examined it carefully. He poked its body and eyes and allowed the dog to sniff at it, but still there was no sign of life. He decided to make a test to find out if the animal was "playing possum." After an hour of observation, he noticed that the animal suddenly moved. It looked carefully around and then scrambled to its feet and made for the woods.

Directions: All of the statements below are related to the situation described above. Read each statement in the list. Is the statement given as a fact or as an assumption? Place a mark in the appropriate column before the statement.

Fact	Assumption	
___	_____	1. The opossum was dead when the boy approached it.
___	_____	2. The opossum "played dead" to protect itself.
___	_____	3. The opossum's behavior is instinctive.
___	_____	4. The opossum lives in tree hollows
___	_____	5. The opossum's tail coiled around the boy's finger.
___	_____	6. The boy found an opossum in a tree hollow.
___	_____	7. The dog does not like the opossum.
___	_____	8. The opossum escaped to the woods.
___	_____	9. The boy knew all the time that the opossum was alive.
___	_____	10. The boy was not sure that the opossum was alive so he tried an experiment.

You may or may not believe it has been adequately demonstrated that "OPOSSUMS ALWAYS PLAY DEAD WHEN IN DANGER." Of the following statements, check the one which best represents your personal opinion.

_____ a. I believe that opossums always "play dead" when in danger.

_____ b. I do not believe that opossums always "play dead" when in danger.

_____ c. I am unable to decide whether or not opossums always "play dead" when in danger.

Write the reasons that you have to support this opinion.

PROVIDING A CLASSROOM LABORATORY EXPERIENCE

One of the objectives of general science is to provide greater pupil participation in laboratory activities. The laboratory experience can be described in terms of various functions. It can provide activities for:

1. Development of skills and techniques
2. Verification of scientific principles
3. Problem solving

Learning through doing and observing is an important ingredient of science. The activities are sequentially arranged in terms of the demands made upon the critical thinking of the pupils and the difficulty of development within the classroom. One measure of the success of the instructional program will be reflected by the degree to which we provide opportunity for these activities.

For problem solving, we can approach the ideal only as problems arise in class, are identified, and a planned solution is attempted. However limited the degree to which we carry out problem solving, it is both rewarding and important. Every time a question arises in class which lends itself to direct experimentation, it should receive the most thorough study. Often only a few pupils or an individual will undertake the solution of a problem. There will be fewer but more significant instances in which the entire class resource can be utilized to reach the experimental solution to a problem. Every success achieved in this area, however limited, will make the next attempt more successful.

Many opportunities exist for providing laboratory activities in which pupils can have the thrill of discovery. This experience is not limited to the solution of abstract problems being investigated in basic research. It will occur whenever a pupil asks why and then attempts to answer his own question by any means at hand. The act of discovery can arise spontaneously, or it can result from the careful planning and structuring of a learning situation in which the elements for discovery are provided.

Although the classroom facilities and class load may not constitute an ideal environment for use of problem-solving methods, difficulties are not insurmountable. Some suggestions for effective use of the classroom laboratory are given in the resource units.

AUDIO-VISUAL MATERIALS

Audio-Visual materials satisfy a variety of needs. They help to:

Create vital experiences for the learner.
Provide a stimulating class environment.
Supply resource material.
Increase understanding.
Build appreciation.
Stimulate creative activity and pupil participation.

To use audio-visual materials most effectively, the teacher must plan carefully and be selective in use of a variety of techniques and devices.

As a preliminary to the use of audio-visual materials, the teacher should familiarize himself with the resources available through the Audio-Visual Section, Instructional Aids and Services Branch. ***Each*** teacher should have ***on file*** and make reference to the following publications:

Catalog of Audio-Visual Materials for Secondary Grades. 1961 Edition. Los Angeles Schools, Publication No. 579.

Catalog of Secondary Films. 1962 Edition. Los Angeles City Schools, Publication No. 530.

Audio-Visual News. This supplement to the film catalog announces new titles and films no longer available. It also provides news regarding other types of audio-visual materials. The newsletter is circulated periodically.

Listed below are some suggestions for use of audio-visual materials in the classroom laboratory.

Films, Filmstrips, and Slides

1. Films. In science teaching, the motion picture stimulates the pupil by creating interest. A film gives animation to motionless things, shows the continuity of a process, and projects the pupils into time and space. It is wise to record reviews of all films used and to keep them for reference in a 3"x5" file. Such a ready reference will assist in the presentations of films as well as in placing future orders. See Publication No. 530 regarding available films.

2. Filmstrips. Both filmstrips and slides have an advantage in that they can be viewed on the screen for extended periods. One frame at a time can be shown in or out of sequence. The filmstrip should be carefully previewed before showing. The time to be allotted for viewing during a given period should be carefully planned. Seldom is it desirable to show the entire filmstrip in a single class period.

   The filmstrip affords the teacher an excellent opportunity to provide guidance in the development of reading skills. Pupils should be allowed the fullest expression of their ideas and encouraged to:

   Interpret pictures and diagrams.
   Generalize the application of ideas to current study.

Note main ideas.
Improve their skill in rate of reading.
Read for exact meaning.

A filmstrip enables the teacher to note vocabulary needs, such as pupil difficulties in understanding the application of scientific principles. See Publication No. 579 regarding available filmstrips.

3. Slides. In most ways, slides can be used in the same manner as filmstrips. Since the teacher must assemble slides and structure their use for his presentation, they can be more directly applicable to current study than filmstrips. Sorted out by subject matter and stored in convenient trays, the slides are a most flexible audio-visual aid. They can be used extensively in the study of both living and nonliving things. Science teachers will find it helpful to use their own cameras in securing original photographs for a particular purpose. Slides also provide a local experience ingredient which relates most positively to pupil encounters with their environment.

The Standard Supplies For General Science List. Provides a description of 2x2 Kodachrome slides which are available for classroom use. In addition the teacher should refer to the supply catalogs of various companies to appreciate the wide range of subject matter for which slides have been prepared.

Pupils should be encouraged to share slide "experiences" with their classmates. Many pupils also find microphotography to be a fascinating hobby.

Slides can be used effectively for such areas as the following:

Local geological formations
Local plant associations
Local tide pool communities
Microscopic objects
Objects used in the study of astronomy
General flora and fauna
National parks
Charts, diagrams, pictures, and other graphic aids reproduced by photo copying technique

Opaque Projector and Microprojector

1. Opaque projectors. These are available in most schools and can be used by the science teacher to show pictures, charts, diagrams, printed text in books, magazines, and pamphlets. Often, there is just one copy of this material available for use by the entire class. Its projection will save time and energy. It is also possible to develop a resource of plates on a variety of topics for use with the projector. Plates can be conveniently stored to await reuse.

2. Microprojectors. This type of projector makes it possible for the entire class to view microscopic objects at one time. It can be used simultaneously with microscope exercises to point out what pupils should look for in various slides which are to be examined individually. The microprojector has a special value when only limited material is available for observation. Anything which can be viewed under the microscope by transmitted light can be projected, including plant and animal tissues, prepared slides, crystals of chemical substances, and various fibers.

Bulletin Board and Flannel Board

1. Bulletin Board. This is an invaluable tool in the science room. It can be used most effectively to:

   Arouse interest in a new unit.
   Maintain the continuity of essential themes of a unit.
   Allow several members of the class to participate in a cooperative project.
   Maintain curiosity about new "doings" in the class.

   Material for bulletin board displays should be painstakingly developed and ***CHANGED OFTEN***. Very effective bulletin board displays can be prepared by pupil teams if the teacher has carefully defined the nature of the theme to be developed. Pupils should be encouraged to submit proposed sketches, assisted with materials to be used, and provided sufficient time for actual construction of the display.

2. Flannel Board. The pupil's imagination can be stimulated with form and color through use of the flannel board. It is an aid in learning situations which involves steps. It simplifies content and encourages participation in learning. The flannel board technique can be used in introducing a unit, emphasizing subject matter, clarifying content, reviewing for a test, and covering material during a test.

   A most dramatic and effective use of the flannel board technique is to employ an entire bulletin board panel as the "flannel board." Black cotton flannel, which may be ordered from the consumable supply list, is placed taut over the bulletin board panel and secured by means of thumbtacks along its margin. Thin strips of construction paper can be used to conceal the thumbtacks.

   Cutouts can be made from construction paper, flocking paper, flannel, felt, and paper with sandpaper backing or flocking. A wire screen placed under the flannel makes possible the use of magnetic tape as a supporting agent for the cutouts. After the lesson or exercise, the cutouts can be stored conveniently for future use.

Television in the Classroom

1. Radio-Television Ways to Learning. Issued eight times a year and available to all schools, this newsletter contains a descriptive log of science television programs. Brief synopses of lessons to be presented include purpose, content, preparation, follow-up activities, and suggested questions for class discussion.

2. Network Radio and Television Programs. These should also be considered as means of further stimulating pupil study and activity. If young people enjoy a program and find in it a stimulus, teachers should consider the possibility of fitting that program into their planning of classroom activities.

3. Effective Viewing. The following checklist for successful classroom viewing is suggested:

   a. Available information checked for suggestions in using program.

   b. Television set ready in the front of the room, properly tuned, and adjusted for good reception.

c. Class prepared and comfortably seated in a light, well-ventilated room.

d. Relaxed, attentive listening by the teacher as well as the class.

e. Time set aside for creative follow-up activities.

f. Every change taken to integrate the program with general learning.

SAFETY REGULATIONS

Safety is always of prime importance. It is ***mandatory*** that teacher and pupils together follow safe practices. In the setting up and handling of materials and equipment, it is necessary to:

Proceed on the basis of accurate knowledge.

Allow sufficient time.

Avoid unnecessary risks by planning and making "dry runs."

ALL TEACHERS SHOULD REFER TO THE *Handbook of Safety Rules and Regulations*, WHICH IS TO BE FOLLOWED AS PRESCRIBED. (See department chairman for a copy of this publication.)

The following regulations illustrate precautions necessary in avoiding accidents.

General Instructions

1. Notify the principal at once of any safety hazard that develops in the room, such as defective gas and electric outlets and connections, defective seats that may cause injury, or a defective fire extinguisher.

2. Assure that the fire extinguisher is inspected by proper authorities at least once during each term.

3. Perform all experiments far enough away from the pupils to assure their safety in case of accident.

4. Do not permit pupils to carry apparatus through the halls when classes are passing.

5. Supervise pupils when they are using sharp-edged instruments.

6. Instruct pupils not to "short circuit" dry cells or storage batteries.

7. Caution pupils not to grasp any electrical device which has just been used. Most electrical devices are hot after use, and serious burns may result.

Using Heat

1. Do not perform any experiments involving the heating of alcohol, strong acids, or strong bases.

2. Never permit gasoline, ether, carbon disulfide, alcohol, or other volatile, inflammable liquids near a flame.

3. If alcohol ignites in a beaker, cover beaker with a glass plate to extinguish flame. If burning alcohol runs over table, use fire blanket.

4. Never point the mouth of a test tube toward your face or toward a neighbor while the tube is being heated.

5. Never permit a completely stoppered container to be heated.

6. Never pass your hand or arm over a lighted burner.

Using Glass

1. Do not cut, manipulate, or use glass tubing unless you have received precautionary instructions from the teacher in charge.

2. Never attempt to insert tubing having a jagged end--always fire polish first.

3. Use water, soap, or glycerine as a lubricant before forcing glass tubing into rubber stoppers. Always aim tubing away from the palm of the hand which holds the stopper or rubber tubing.

4. Always hold glass tubing as close as possible to the part where it is entering the rubber stopper. A cloth wrapped around the hand or tubing at the point of contact with the hand will help avoid injury if the glass breaks.

Using Chemicals

1. Make certain that all combustible and dangerous materials, such as poisons and acids, are kept securely locked in a metal cabinet, and that pupils do not have access to such a cabinet.

2. Place large storage bottles of acids and other dangerous chemicals on glass plates on the floor of the cabinet.

3. Handle with greatest care concentrated acids and strong alkalies.

4. Never place bottles containing acids or organic volatile liquids near heat, nor allow them to stand in the sun, as dangerous gas pressures may be built up.

5. Do not use the following materials for ***experimentation or demonstration:***

   a. Phosphorous (red or yellow)

   b. Metallic sodium

   c. Material capable of generating poisonous gases

   d. Hydrogen gas

   e. Potassium chlorate

   f. Other materials subject to explosion

6. Never add water to concentrated sulphuric acid. Prepare dilute acids by adding small quantities of concentrated acid to water. During this process, stir the solution constantly.

Using Radioisotopes

After careful study of the safety considerations involved, radioactive isotopes in limited quantities have been approved by the United States Atomic Energy Commission for classroom use.

The use of these materials should be limited to ***teacher demonstration*** in amounts prescribed by *Handbook of Safety Rules and Regulations*, 2370-51.

1. Keep radioisotopes under lock and key when not in use to avoid handling by unauthorized persons.

2. Spread waterproof paper over working areas to simplify "clean-up."

3. Use tongs or tweezers in handling containers and specimens.

4. To avoid spillage, clamp all bottles and other containers which hold radioactive substances.

5. Avoid ingestion or inhalation of radioactive materials.

6. Do not place pipette in mouth; use pipette control device, rubber bulb, or medicine dropper.

7. Avoid contamination of hands. Wash hands after each experiment with radioactive isotopes; test with Geiger counter. Remove "contamination" with a soft brush and soap; scrub for 10 minutes ***BY THE CLOCK*** ("surgical scrub").

8. Avoid conducting demonstrations that would result in radioactive fumes.

9. After use of radioactive materials, dispose of liquid wastes by pouring them down drain and flushing the sink with water. Dispose of paper and solid wastes by wrapping in paper and incinerating promptly.

Using Animals

1. Handle laboratory animals carefully. Permit pupils to handle them only ***under supervision*** so that danger of being bitten may be avoided. Heavy gloves should be used if there is any suggestion of biting on part of the animals. Animals that show a tendency to bite should not be kept in the classroom.

2. Caution pupils not to insert fingers in the wire mesh of cages. Use appropriate warning signs on cages, such as "KEEP HANDS OFF."

3. If pupil is bitten by a laboratory animal in the classroom, notify the health coordinator or principal for further directions.

4. DO NOT KEEP POISONOUS ANIMALS IN THE CLASSROOM.

5. To comply with Animal Care Act, observe the following:

   a. Keep for observational purposes only; do not conduct experimentation adversely affecting their health.

   b. Have animals in clean and comfortable cages.

   c. Assure that animals are fed and watered daily during school days and that sufficient food and water are provided for Saturdays and Sundays if left on school premises.

   d. Assure that cages are cleaned periodically by scrubbing with boiling water and disinfectant.

e. Ask custodian to dispose of refuse and dead animals.

Involving Pupils

1. Before involving pupils in any arduous activity or exercise, consult with health coordinator to identify those who have been excused from regular Physical Education classes or who have disabilities which require special consideration.

2. Assure that various devices, such as a stethoscope, be sterilized before use in any experiments involving pupil contact. The devices must also be sterilized before subsequent use by another pupil.